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by

Abdul R. Kiwan

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6 FAE FLOW COMPUTATIONS USING AFAMF CODE, (U)

10 Abdul R. Kiwan

Applied Mathematics Division

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BALLISTIC RESEARCH LABORATORIES

REPORT NO. 1547

ARKiwan/bj
Aberdeen Proving Ground, Md.
September 1971

FAE FLOW COMPUTATIONS USING AFAMF CODE (U)

(UNCLASSIFIED) ABSTRACT

This report explains how one may use the AFAMF code to compute approximately the flow arising from the detonation of a cloud of fuel air mixture. A scaling method is given to effect a comparison of computed results with experimentally measured values.

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LIST OF SYMBOLS

r_j	radial distance
$\bar{r}_j$	dimensionless radial distance
R_o	radius of volume equivalent spherical cloud
P_d	detonation pressure
P_s	pressure at the surface of the cloud (or piston)
P_o	ambient atmosphere pressure
P_h	shock overpressure
2N	number of mesh points in initial wave
Z_h	dimensionless variable

(UNCLASSIFIED) I. INTRODUCTION

In an earlier report [1]* a model has been developed to approximate the flow which arises from the detonation of a spherical cloud of a fuel-air mixture. This model uses a G. I. Taylor [2] self similar wave to simulate the flow during the detonation process. After the detonation ends the flow is computed by finite difference methods. The surface of the cloud is held stationary after the end of the detonation process to avoid the computational difficulties of a contact surface. This imposed constraint has the effect of starting a rarefaction wave propagating into the flow field in our computation earlier than it happens in the actual physical phenomena. In the earlier report [1] it is shown how one computes various quantities which are important in the assessment of the damage resulting from such clouds. Experimental results exist for a variety of clouds of various shapes and of various fuels. In this report it is intended to show how one can scale these results in order to effect a comparison with the computations given in [1].

(UNCLASSIFIED) II. SCALING OF RESULTS AND COMPARISON WITH EXPERIMENT

Given the chemical composition of the cloud of fuel and the mole percentage of fuel to air in the mixture one can compute the detonation pressure P_d of this mixture. To compute P_d there are a variety of codes which can do this such as TIGER, TAMER, and FAE. Through an interpolation one determines a value of α which gives a wave with the pressure at the surface of the cloud P_s equal to P_d. Table I gives corresponding values of α and P_s/P_o which can be usefully employed for such a purpose. Essentially the parameter α determines the piston's velocity which produces the desired wave. Since most of the available experimental results are for clouds which are not spherical one has to measure the volume of the cloud and then compute the radius R_o of the sphere which has an equal volume. From the computations one obtains the shock

*References are listed on page 12.

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over pressure P_h as a function of the position $\overline{r}_j$ in dimensionless radial distance, where

$$\overline{r}_j = 1 + (j-2)\Delta r \ , \tag{1}$$

$$\Delta r = [\mathrm{Exp}(z_h) - 1]/2N \ . \tag{2}$$

To convert to dimensional distances let

$$r_j = R_o \, \overline{r}_j \ . \tag{3}$$

A plot of P_h Vs. r_j is made to compare with those measured experimentally after converting P_h to Psi. For a 4% mixture of $CH_3CH_2CH_2NO_3$ normal-propyl nitrate (NPN) and 96% air it was found that the detonation pressure P_d = 18 atmospheres. The interpolated value of $\alpha = 1.77616$ gives $P_s/P_o = 17.9865$. The flow computations of this case was performed using the AFAMF code developed and described in [1]. A plot of the computed shock overpressure as a function of distance was made in Figure 1 for a spherical cloud of radius R_o = 11.6 ft. of the above described composition. Experimental data were later on obtained from TBL and plotted in Figure 1 to effect a comparison. The experimental values plotted in Figure 1 are mean values in the sense that they are taken from a curvilinear fit of mean experimental values. Figure 2 shows computed values of the static and dynamic impulse for such a cloud plotted as functions of distance from the center of the cloud. The comparison of experimental and computed overpressures indicates that this code can be profitably used to predict the flow from such clouds. From Figure 1 it appears that the approximation is a good one. To compute the reflected shock pressures one can refer to the theory developed in [3], or for normal reflections use the results of Shear and McCane [4].

(U) TABLE I (U)

α	P_s/P_o	α	P_s/P_o	α	P_s/P_o
0	1.0	.8	2.1389	1.6	10.3751
.1	1.0189	.9	2.5108	1.7	13.8711
.2	1.0704	1.0	2.9725	1.8	19.7021
.3	1.1517	1.1	3.5482	1.9	31.2932
.4	1.2639	1.2	4.2734	2.0	65.2023
.5	1.4113	1.3	5.2012	2.1	1676.1990
.6	1.6004	1.4	6.4157		
.7	1.8397	1.5	8.0566		

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The author acknowledges gratefully the kind and generous help of Mr. R. E. Shear and Mr. C. Kingery. The author is grateful to Mr. Henry Wisniewski for his fine programming effort.

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[4] Shear, R. E. and McCane, P., Normally Reflected Shock Front Parameters, Ballistic Research Laboratories Memorandum Report No. 1273 (1960).

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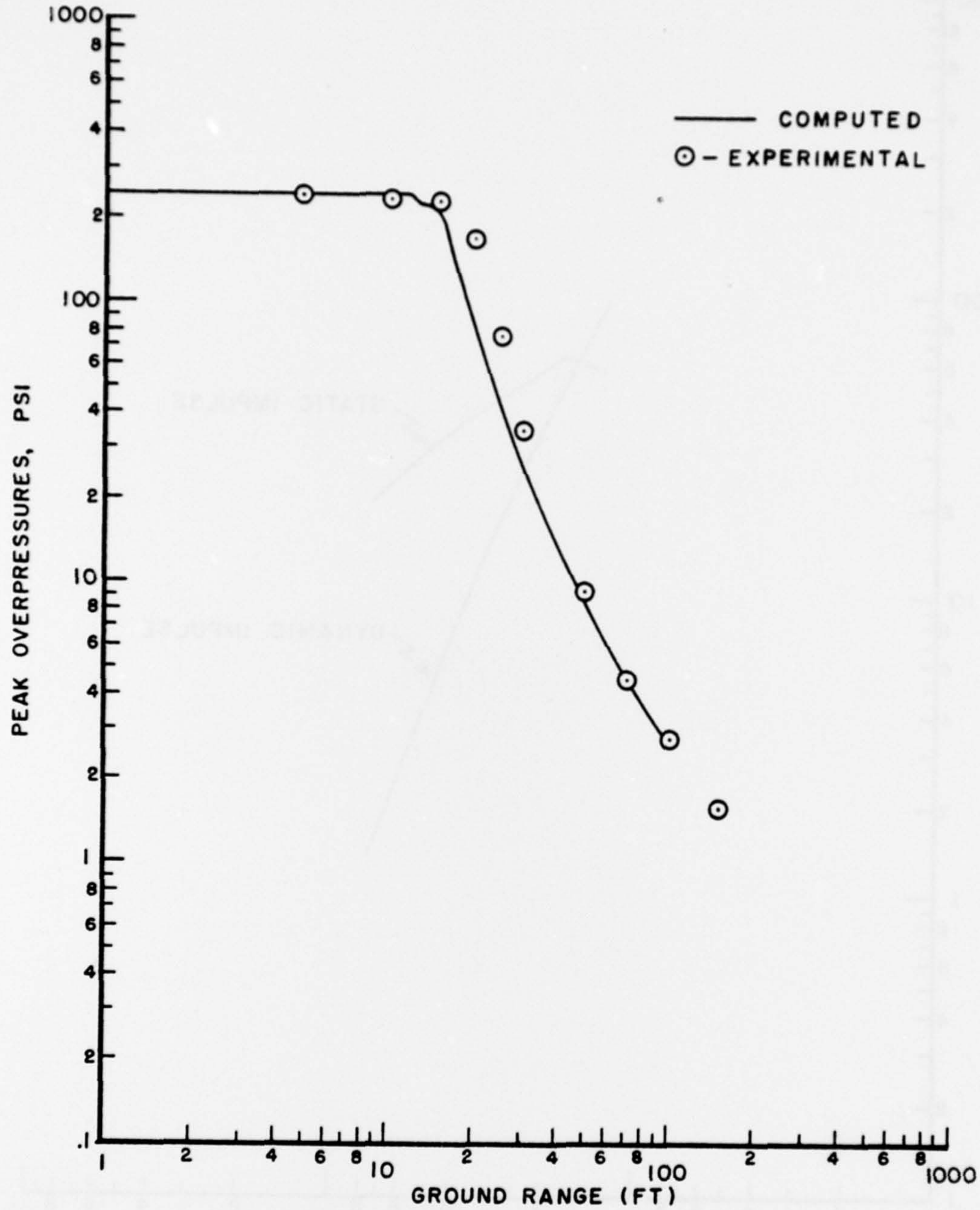

[redacted] Figure I. (U)

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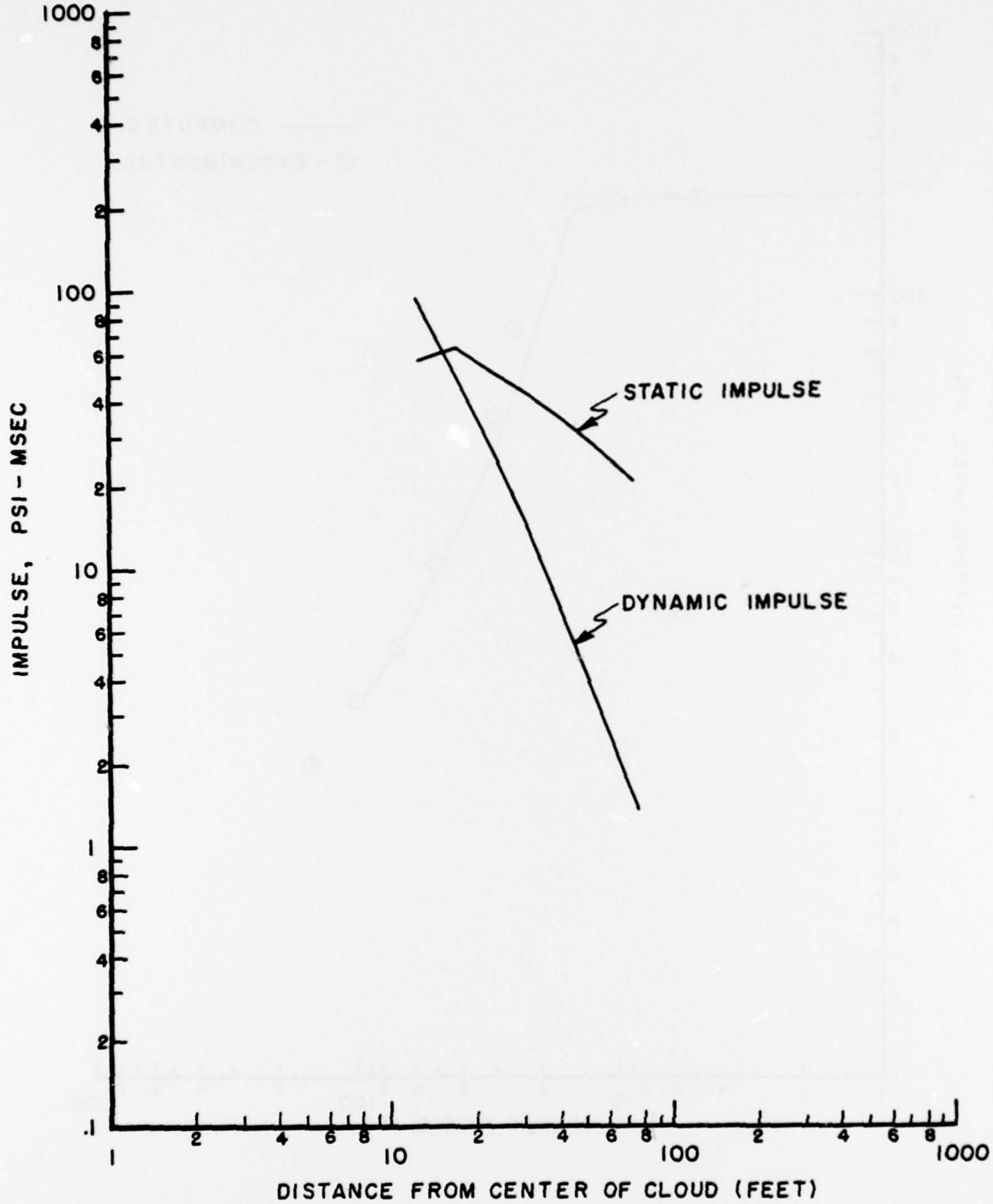
IMPULSE, PSI - MSEC
1000
100
10
1
.1
1
10
100
1000
DISTANCE FROM CENTER OF CLOUD (FEET)
STATIC IMPULSE
DYNAMIC IMPULSE

(U) Figure 2.

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